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14. ABSTRACT De-painting aircraft is a standard step in the corrosion control processes found on nearly every Air Force installation. Depot-level de-painting processes often use hazardous chemicals to remove coatings from aircraft and support equipment. However, these chemical strippers and sanding techniques typically have serious health and environmental concerns associated with their use as well. These concerns have led to research in alternative de-painting methods. Currently, laser ablation de-painting is being investigated as an alternative and/or supplemental de-painting method at the depot and field levels. AFIOH provided an assessment of this process, which took place in a laboratory setting; however, all removed coatings were standard aircraft primers and paints from the Air Force supply system. Laser ablation is achieved by using pulsed high energy Class 4 lasers that create bursts of high intensity energy. Laser ablation is a mechanical process. A shock wave is created by vaporizing a thin layer of coating into plasma. The shock wave removes the coating and creates a crack network in the remaining coating. Paint substrates are reduced to atomic levels with some recombination at the molecular level. Portable HEPA ventilation is tied to the system and collects particles and gases at the laser head. AFIOH assessed controls and contaminants created by the ablation including laser hazards, noise, carbon dioxide, carbon monoxide, nitric oxide, hydrogen cyanide, formaldehyde, and metals including chromium VI. Further assessment is still needed, but initial sampling found promising <OEL results.				
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c. THIS PAGE U				



DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE FOR OPERATIONAL HEALTH (AFMC)
BROOKS CITY-BASE TEXAS

29 Apr 05

MEMORANDUM FOR AFRL/MLSC

FROM: AFIOH/RSHI
2513 Kennedy Circle
Brooks City-Base, TX 78235-5116

SUBJECT: Consultative Letter, IOH-RS-BR-CL-2005-0044, Evaluation of Laser De-Painting System

I. INTRODUCTION

a. *Purpose:* On 1-2 March 05, the Industrial Hygiene Branch of the Air Force Institute for Operational Health (AFIOH/RSHI), per the request of HQ AFMC Bioenvironmental Engineering (HQ AFMC/SGPB), performed an exposure assessment of the Cleanlaser depainting system. This survey was performed as a pre-field use evaluation of this system. This letter provides the results of our evaluation.

b. *Survey Personnel:*

Capt David DeCamp, AFIOH/RSHI, Industrial Hygiene Consultant
Capt Ian Rybczynski, AFIOH/RSHI, Industrial Hygiene Consultant
TSgt Henry DeBose, AFIOH/RSHI, Industrial Hygiene Technician
SSgt Gabriel Almario, AFIOH/RSHI, Industrial Hygiene Technician
SSgt Justin Murphy, AFIOH/RSHI, Industrial Hygiene Technician

c. *Personnel Contacted:*

Lt Col Michael Elliot, HQ AFMC/SGPB
Tim Sumpter, AFRL/MLSC
Harold Hall, AFRL/MLSC
Derek Upchurch, AFRL/MLSC

d. *Equipment Used:*

SKC Air Check Sampler (Model 224PCXR8)
BIOS DryCal DC-Lite Primary Flow Meter
Metrosonics AQ-5000 Indoor Air Quality Meter
Quest Technologies SoundPro DLX-2-1/1 Sound Level Meter
Quest Model QC-10 Acoustic Calibrator

Solar Light PMA2141 Class II Pyranometer
Solar Light PMA2100 Photometer

2. BACKGROUND:

a. *De-Painting.* De-painting aircraft is a standard step in the corrosion control processes found on nearly every AF installation. Depot-level de-painting processes can use chemicals such as methylene chloride or similar chemical strippers to remove coatings from aircraft and support equipment. However, these chemical strippers typically have serious health and environmental concerns associated with their use as well. These concerns have led to research in alternative de-painting methods. Currently, laser de-painting is being investigated as an alternative and/or supplemental de-painting method at the depot and field levels.

b. *Laboratory Study:* For this assessment, AFIOH was asked to look at a laser de-painting system that is being considered for field use. This assessment took place in a laboratory setting; however, all removed coatings were standard aircraft primers and paints from the AF supply system. The coatings were applied to two-foot square aluminum or composite test panels and these panels were painted under the same technical requirements established for aircraft painting.

c. *Cleanlaser.* The Cleanlaser optical machining system was developed for use in industrial cleaning processes. The Cleanlaser 120 Q is an ANSI Class IV laser operating at 120 W average power at a nominal wavelength of 1,064 nm. The laser and laser system chiller are mounted on a cart for mobile operation (Figure 1). The laser beam is delivered via fiber optical cables and a manually operated laser head. The laser system was used with a Fumex FA2 HEPA filtration unit, which removes de-painting products at the laser head. Paint is removed from the substrate via laser ablation.



Figure 1. Cleanlaser 120 Q System

d. *Laser Ablation:* Laser ablation (Figure 2) is achieved by using pulsed lasers that create bursts of high intensity energy. Although it may seem otherwise, laser ablation is a mechanical process. A shock wave is created by vaporizing a thin layer of coating into plasma. The shock wave removes the coating and creates a crack network in the remaining coating. There are different variations of the ablation mechanisms that can be observed depending on the laser beam characteristics. These characteristics include power, wavelength, pulse width, pulse frequency, beam profile, and operating parameters.

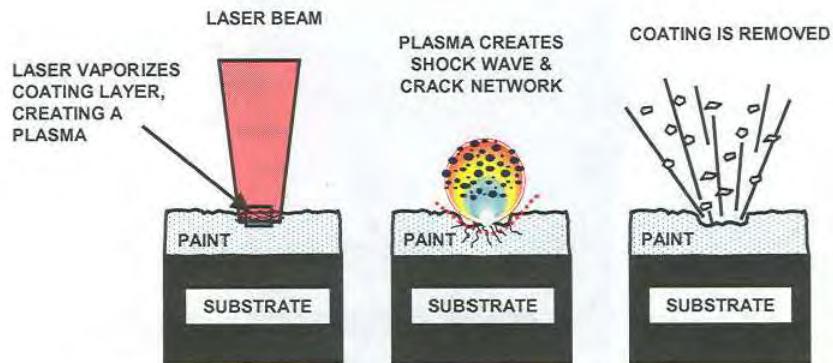


Figure 2. Illustration of Laser Ablation Mechanism

e. *Removal Process.* During de-painting tasks, the operator is required to place the laser head above the substrate surface and move the head over all areas where paint removal is required (Figure 3). Additional pictures of the process are shown in attachment 1. Repeated passes might be necessary to ensure complete coating removal. The laser head had rollers on it that allowed the operator to easily maneuver the laser head around the square test panels. The laser was turned on and off with a simple trigger system and the laboratory was equipped with interlocks on both entry doors.



Figure 3. De-painting a test plate

f. *Ventilation System.* A Fumex F-2 portable ventilation system was incorporated into the laser head. The Fumex system connects directly to the laser head and has a HEPA collection bag. After particles are removed within the collection bag, the exhaust air is sent to the building's industrial ventilation system, which eventually sends the air to a stack. The capture port was located directly behind the laser and the system was designed to capture the removed coating particles. Figures 4 and 5, below, depict how the ventilation system is incorporated into the laser head.



Figure 4. Laser head with operational nozzle



Figure 5. Laser head with nozzle removed. (Not operational configuration)

3. PROCEDURES

a. *Assessment Strategy:* Although laser ablation has been used for years, health hazards associated with this type of paint removal process are not well evaluated. Thus, AFIOH performed a complete assessment of the key hazards: laser radiation, airborne, and noise exposures. Ergonomic hazards also exist; however, AFIOH has already addressed the ergonomic issues associated with this Cleanlaser system in IOH-RS-BR-CL-2004-0030. Prior to our assessment, available literature on laser ablation were reviewed to limit our air sampling to the most likely contaminants. After reviewing the data, we decided to sample for metals, hydrogen cyanide, nitrogen oxide, nitrogen dioxide, carbon dioxide, carbon monoxide, and formaldehyde.

Although isocyanate-based paints are used, it is expected that these paint components have already reacted during the polymerization process. Although ‘complete’ reaction is always debatable, our research indicated measurable levels of isocyanates were highly unlikely during the ablation process.

b. *Substrate Differences*: The testing facility had two substrates available for us to assess: aluminum and composite. Although paint removal was performed on both substrates during a single day, we separated our assessments by substrate. We did this because we were interested in determining if substrate had an effect on exposure levels.

c. *Media and Collection Methods*:

(1) Metals: NIOSH Method 7300, *Elements by Inductively Coupled Plasma Spectroscopy (ICP)*, which employs a 37-mm closed face cassette containing a 0.8- μm mixed cellulose ester (MCE) filter, was used to sample airborne aluminum, barium, cadmium, chromium, copper, iron, lead, nickel, strontium, titanium and zinc.

(2) Hexavalent Chrome: NIOSH Method 7605, *Cr(VI) by Ion Chromatography*, which employs a 37-mm closed face cassette containing 5.0- μm polyvinyl chloride (PVC) filter, was used.

(3) Hydrogen Cyanide: NIOSH Method 6010, *HCN by Visible Absorption Spectrophotometry (VAS)*, which employs a 600/200 mg soda lime sorbent tube was used.

(4) Nitrogen Oxide/Dioxide: NIOSH Method 6014, *Nitric Oxides by VAS*, which employs a 400/200 mg triethanolamine treated molecular sieve sorbent tube, was used. A Metrosonics aq-5000 Indoor Air Quality (IAQ) meter was also used to monitor nitrogen dioxide (NO_2). The resolution for the NO_2 sensor was 0.1 ppm.

(5) Carbon Monoxide/Dioxide: A Metrosonics aq-5000 Indoor Air Quality (IAQ) meter was used to monitor carbon monoxide(CO)/dioxide(CO_2). The resolution for both the CO and CO_2 sensor was 1 ppm. Measurements were taken and logged once a second for the duration of the de-painting processes.

(6) Noise: A Quest Technologies SoundPro DLX-2-1/1 was used to measure the sound pressure level. The calibration was checked with a Quest Model QC-10 acoustic calibrator before and after sampling and found to be within ± 0.3 dB.

(7) Laser Radiation: A Solar Light PMA2141 class II pyranometer connected to a Solar Light PMA2100 photometer was used to measure the reflected scattered irradiance from the handheld laser during use.

(8) Ventilation: A TSI VelociCalc Plus ventilation meter was used to measure capture velocity. Measurements were taken at the center of the nozzle’s capture port.

4. RESULTS

a. *Airborne Exposure Limits:* AFOSH Standard 48-8, *Controlling Exposures to Hazardous Materials*, adopts the most stringent Occupational Exposure Limits (OEL) of either the Permissible Exposure Limits (PELs) set by the Occupational Safety and Health Administration (OSHA), or Threshold Limit Values (TLVs) adopted by the American Conference of Governmental Industrial Hygienists (ACGIH).

(1) Aluminum Substrate De-Painting Process:

Table 1. Laser Ablation on Aluminum Plate Day 1

Analyte	Sample Time (min)	Sample Results (mg/m ³)	8-Hour TWA	8-Hour TWA- OEL Standard (mg/m ³)
Aluminum	120	<0.00298	<0.000745	10
Barium	120	<0.000595	<0.000149	0.5
Cadmium	120	<0.000298	<0.0000745	0.005
Chromium	120	0.000595*	0.000149*	0.5
Chrome (VI)	124	0.0000590*	0.0000152*	0.01
Copper	120	<0.00298	<0.000745	1
Iron	120	<0.00595	<0.00149	5
Lead	120	<0.00149	<0.000373	0.05
Nickel	120	<0.00149	<0.000373	1
Strontium	120	<0.000298	0.000149*#	0.0005#
Titanium	120	<0.000298	<0.0000745	n/a
Zinc	120	<0.00298	<0.000745	n/a
Formaldehyde	117	<0.00547	<0.00133	2.46
Nitric Oxide	119	<0.168	<0.0417	30
Nitrogen Dioxide	119	<0.168	<0.0417	5.6
Hydrogen Cyanide	130	<0.0769	<0.0208	11

Notes: < indicates a non-detect sample and is followed by maximum possible concentration.

* indicates blank corrected value

Strontium Chromate

Table 2. Laser Ablation on Aluminum Plate Day 2

Analyte	Sample Time (min)	Sample Results (mg/m ³)	8-Hour TWA	8-Hour TWA- OEL Standard (mg/m ³)
Aluminum	132	<0.00236	<0.000649	10
Barium	132	<0.000473	<0.000130	0.5
Cadmium	132	<0.000236	<0.0000649	0.005
Chromium	132	0.00236*	0.000649*	0.5
Chrome (VI)	132	0.0000553*	0.0000152*	0.01
Copper	132	<0.00236	<0.000649	1
Iron	132	<0.00473	<0.00130	5
Lead	132	<0.00118	<0.000325	0.05
Nickel	132	<0.00118	<0.000325	1
Strontium	132	<0.000236	0.0000152*#	0.0005#
Titanium	132	<0.000236	<0.0000649	n/a
Zinc	132	<0.00236	<0.000649	n/a
Formaldehyde	127	<0.00504	<0.00133	2.46
Nitric Oxide	137	<0.145	<0.0414	30
Nitrogen Dioxide	137	<0.145	<0.0414	5.6
Hydrogen Cyanide	136	<0.0735	<0.0208	11

Notes: < indicates a non-detect sample and is followed by maximum possible concentration.

* indicates blank corrected value

Strontium Chromate

Table 3. STEL Sampling

Analyte	Sample Time (min)	Sample Results (mg/m ³)	STEL Standard (mg/m ³)
Formaldehyde	15	<0.0107	0.37
Nitrogen Dioxide	17	<0.159	9
Hydrogen Cyanide	15	<0.667	5

(2) Composite Substrate De-Painting Process:

Table 4. Laser Ablation on Composite Plate

Analyte	Sample Time (min)	Sample Results (mg/m ³)	8-Hour TWA	8-Hour TWA- OEL Standard (mg/m ³)
Aluminum	90	<0.00397	<0.000744	10
Barium	90	<0.000794	<0.000149	0.5
Cadmium	90	<0.000397	<0.0000744	0.005
Chromium	90	<0.000794	<0.000149	0.5
Chrome (VI)	91	0.0000804*	0.0000152*	0.01
Copper	90	<0.00397	<0.000744	1
Iron	90	<0.00794	<0.000149	5
Lead	90	<0.00198	<0.000371	0.05
Nickel	90	<0.00198	<0.000371	1
Strontium	90	<0.000397	0.0000152*#	0.0005#
Titanium	90	<0.000397	<0.0000744	n/a
Zinc	90	<0.00397	<0.000744	n/a
Formaldehyde	83	<0.00578	<0.0010	2.46
Nitric Oxide	90	<0.222	<0.0416	30
Nitrogen Dioxide	90	<0.222	<0.0416	5.6
Hydrogen Cyanide	90	<0.111	<0.0208	11

Notes: < indicates a non-detect sample and is followed by maximum possible concentration.

* indicates blank corrected value

Strontium Chromate

b. *Indoor Air Monitoring:* In order to measure CO and CO₂, a direct reading monitor was used. The results of these measurements are presented in Table 5, below.

(1) Aluminum Substrate De-Painting Process:

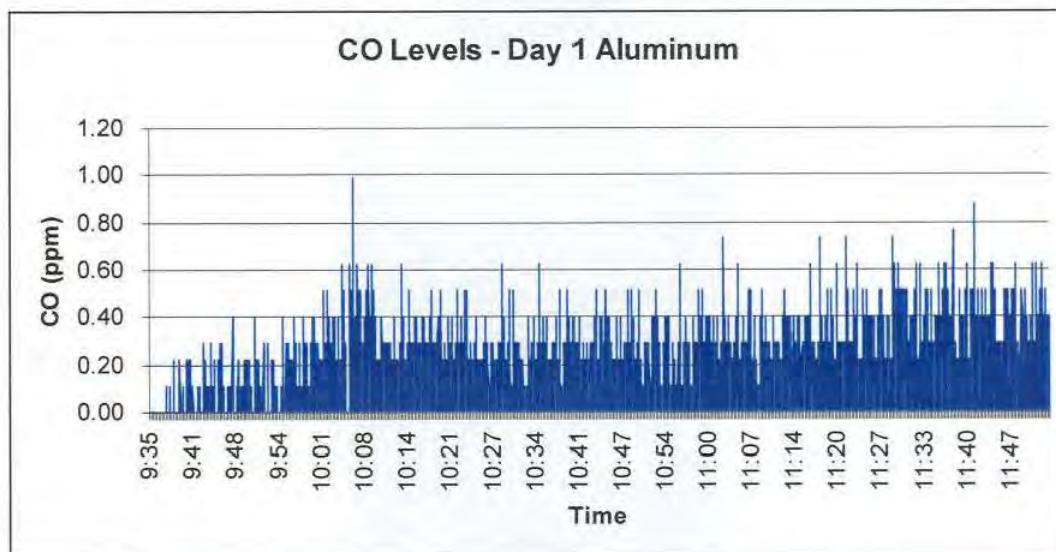


Figure 6. CO levels during first day of aluminum plate de-painting.

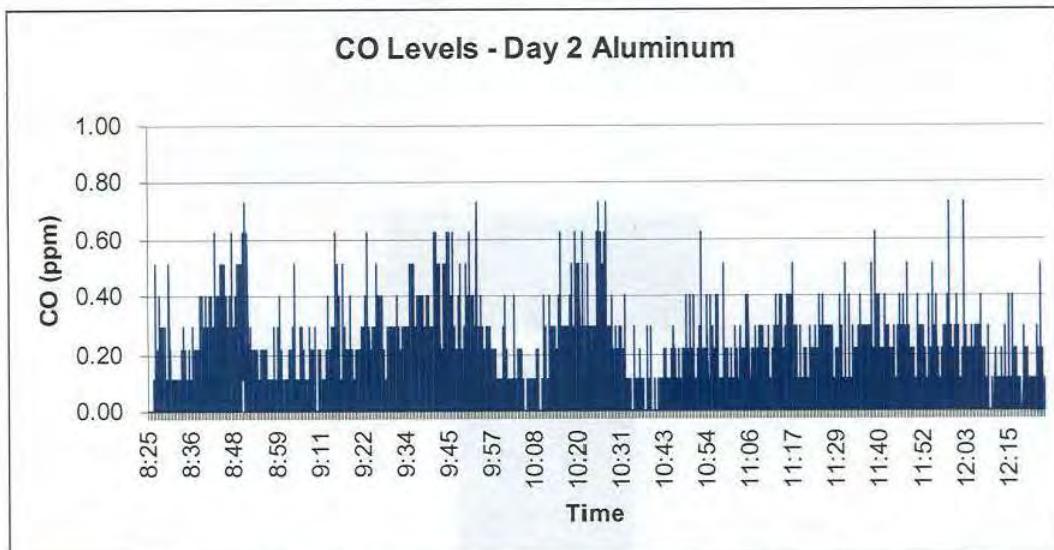


Figure 7. CO levels during second day of aluminum plate de-painting.

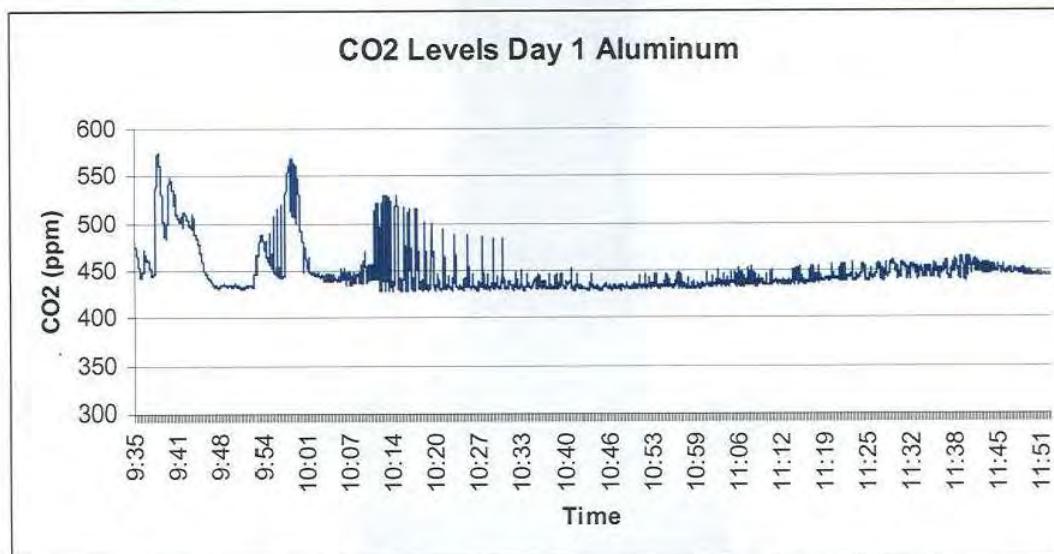


Figure 8. CO₂ levels during first day of aluminum plate de-painting.

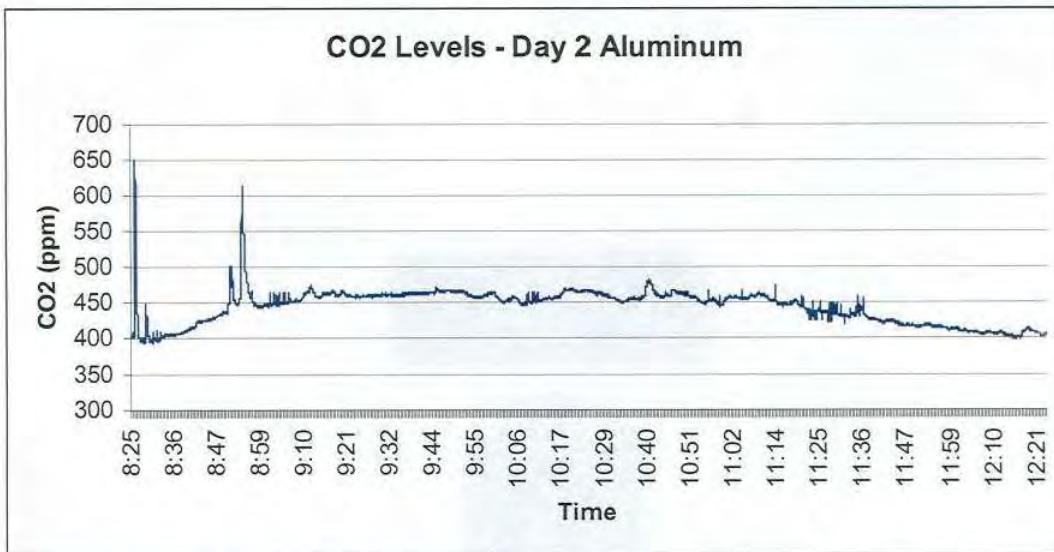


Figure 9. CO₂ levels during first day of aluminum plate de-painting.

(2) Composite Substrate De-Painting Process:

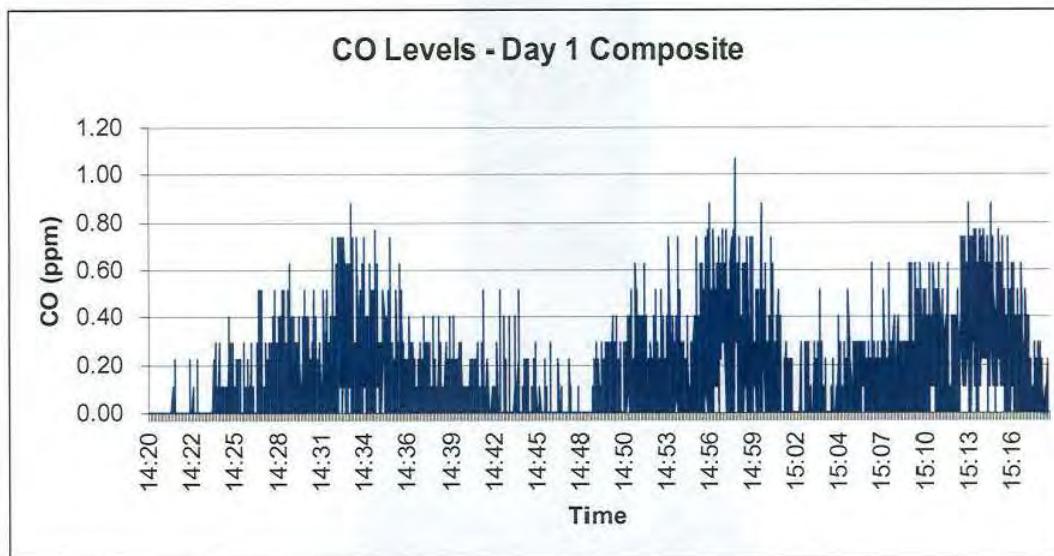


Figure 10. CO levels during composite plate de-painting.

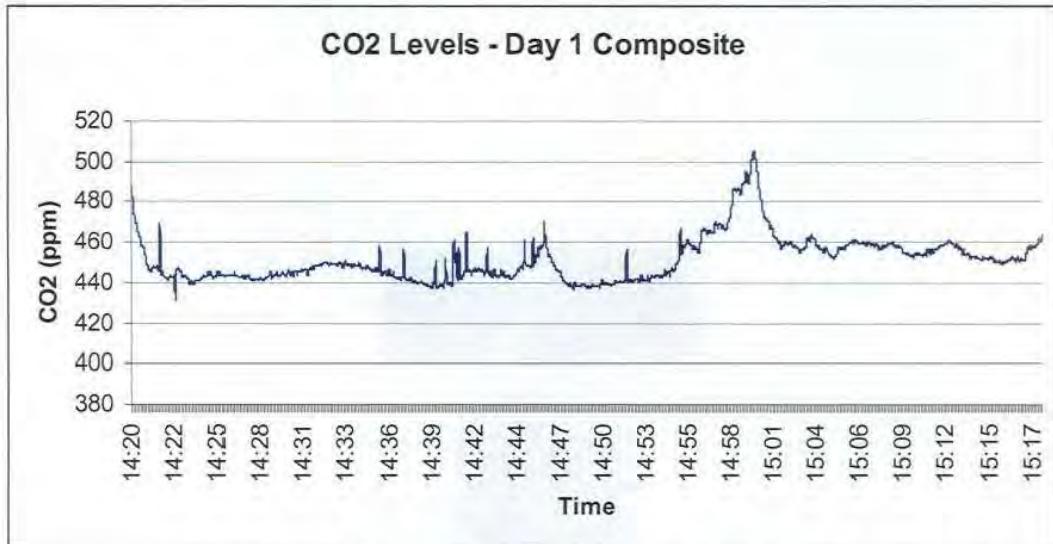


Figure 11. CO₂ levels during composite plate de-painting.

c. *Noise Levels:* The table below contains sound pressure levels measured during paint removal operations. Six sound level measurements were taken near the worker's ear. Measurements were taken for two different operators and for both substrates.

Table 5. Measured Octave Band Sound Pressure Levels (SPLs) Near the Worker's Ear

Octave Band Center Frequency, Hz	Measured Octave Band SPLs Near the Worker's Ear, dB						Geometric Mean SPL, dB
31.5	34.1	37.2	35.2	35.3	32.6	34.1	34.8
63	42.5	42.4	44.8	44	46.5	45.7	44.3
125	59.2	63.5	61.7	61.5	63	61.3	61.7
250	65.5	66.1	67	68.3	66.5	68.4	67.0
500	72.7	70.2	73.7	75.5	72.7	72.6	72.9
1000	73.5	73	74.9	76	73.8	73.7	74.2
2000	76.3	74.7	72.8	74.4	72.1	72.6	73.8
4000	73.9	72	73.1	71.1	71.3	69.6	71.8
8000	72.2	67.6	76.1	70.9	70.6	73.8	71.9
Calculated dB(A)	81.2	79.5	81.0	80.8	79.1	79.4	80.0

d. *Laser Radiation.*

(1) The Cleanlaser 120 Q is a Class 4 laser as defined in paragraph 3.3 of the American National Standards Institute (ANSI) Standard Z136.1-2000, *American National Standard for the Safe Use of Lasers*. A hazard analysis of the laser was preformed with the current USAF approved laser hazard analysis software (LHAZ), IAW paragraphs 3.2 and A3.2.6 of AFOSH Standard 48-139, *Laser Radiation Protection Program*. Based on data from Adapt Laser

Systems (service center in the U.S. for the Cleanlaser), the following parameters were entered into LHAZ version 4.4.26:

Parameters entered into LHAZ	
Wavelength:	1064 nm
Output Mode:	Multiple pulse
Average Power:	100 W
Energy Per Pulse:	12.5 mJ
Pulse Duration:	120 ns
PRF:	8 kHz
Beam Profile:	Circular
Beam Distribution:	Top hat
Beam Divergence:	75 mrad
Beam Waist Diameter:	0.4 mm
Beam Waist Range:	10 cm
Output Aperture Diameter:	1.5 cm
Source Size:	0 (conservative)

(2) Attachment 1 lists the variable parameters for the Cleanlaser system. The chosen values for LHAZ of the variable parameters were determined from the “worst-case” optical density calculation and do not represent the typical operational settings. The results from the calculations are shown in the following table. From discussion with the contractor testing the laser, the pulse repetition frequency (PRF) is set usually between 15 to 18 kHz. The thickness of the paint determines the appropriate PRF. The scan width is set usually to 50 mm and the scan speed is usually between 70 to 100 Hz.

MPE Computations:		Diffuse Reflection Hazard Analysis:	
Exposure Duration:	10 seconds		
Hazard Distances and OD Requirements:		Diffuse Reflection Hazard Analysis:	
Ocular		Ocular	
Exposure Duration:	10 seconds	Exposure Duration:	600 seconds
NOHD:	30.9 cm	NHZ:	0 cm
At Viewing Distance:	10 cm	At Viewing Distance:	100 cm
Maximum OD:	5.04	OD Required:	0
Skin		Skin	
Exposure Duration:	600 seconds	Exposure Duration:	600 seconds
NOHD:	1.6 cm	NHZ (Skin):	0.00 cm
At Exposure Distance:	10 cm	At Exposure Distance:	100 cm
Maximum OD:	3.02	OD Required:	0

(3) The PMA2141 has a very flat response from 305 to 2800 nm (1604 nm for Cleanlaser) and has very little response outside of this region. The pyranometer read up to 0.3 mW/cm² within the room when the laser was not operating. The highest measurement recorded with the pyranometer during operation of the laser was 15.9 mW/cm², which was measured about six inches away from the laser to the right of the worker's position for about two seconds. Since the laser is constantly moving during operation, the integrated dose measured at any given point in space was relatively small.

e. *Ventilation Measurements.* Face velocity ventilation measurements were used to evaluate the performance of the system. Table 6, below, lists our measurements. Measurements were taken at startup and after every 30 minutes of de-painting tasks. A new HEPA filter bag was in place at the start of the operation and it was replaced between measurements 8 and 9.

Table 6. Face Velocity Ventilation Measurements

Mesurement Number	Face Velocity (f/min)
1	5640
2	5000
3	4810
4	5325
5	4760
6	4480
7	3800
8	3900
9	6300
10	5800
11	5400
12	6250

5. DISCUSSION

a. *Airborne Exposures:*

(1) Our air sampling results indicated that operator airborne exposures were very low. No calculated exposure levels were above an OEL or an action level. In fact, the only air sample results that came back with detectable levels were our samples for chromium. However, the chromium results are most likely caused by filter contamination, not actual airborne levels. (This is a known problem with SKC filters. Blanks have consistently had detectable levels for years). We sent in four MCE blanks for this effort and the lab reported 0.255, 0.261, 0.321, and 0.453 µg/sample. All of our 7300 air sampling results were below the high value in the range of our blanks and no other metals had detectable levels; thus, it is reasonable to assume all chromium results were from filter contamination. We had this same problem with our hexavalent chrome samples. We again had the lab analyze four PVC blanks and the lab reported none detected, 0.0300, 0.0540, 0.0620 µg/sample for these blanks. In the results section, we reported a blank corrected airborne exposure level; however, given the range of our blank results, it is once again

reasonable to conclude all hexavalent chrome results were caused by filter contamination. Regardless of where the chromium came from, all calculated exposure levels were below the AF OELs. No differences based on substrate were noted for airborne exposures.

(2) The indoor air quality meters allowed us to continuously monitor carbon monoxide and carbon dioxide levels within the work area. Significant increases in CO or CO₂ were not noted during our survey. We were most interested in seeing if there were any significant CO levels because this could indicate that some chemical reactions were occurring during the ablation process; however, our CO monitoring didn't indicate any significant CO production at any time during the day and half of de-painting operations. Although there has not been significant research on the breakdown of polyurethane paints during heating, research on polyurethane foams has indicated CO, NOX, and HCN production is most likely. Combustion processes typically yield smaller carbon molecules, so we also looked to see if there was any formaldehyde production; however, we did not find detectable levels of NO, NO₂, HCN, or formaldehyde. Again, no substrate-based differences were noted.

(3) CO₂ can also be produced during the combustion of polyurethanes, but the spikes we saw could have been produced from worker respiration as well. Given the lack of other gasses found, it seems reasonable that the latter explanation was the cause of our occasional CO₂ spikes. The CO₂ results were normal for any indoor workspace. Although we did not measure throughout the workday is an indicator that the workspace itself had good dilution ventilation.

b. *Hazardous Noise:* The highest measured weighted sound pressure level near the ear was 82.5 dB(A) and 84.5 dB(C). Based on these results, workers who operate the Cleanlaser would not be exposed to hazardous noise levels. However, the laboratory environment where the measurements were conducted do not realistically account for other noise sources found in a typical corrosion control hangar. Also, in the laboratory setting, the operator was leaning over a table with the handheld laser. In the operational environment, the worker might be placing the handheld laser in many different positions relative to his body. Figure 12, below, shows that the sound pressure level will increase by about 10 dB if the worker positions the laser near his head (e.g., due to limited space). At this exposure level, depending on the exposure time, the worker could be exposed to hazardous noise levels IAW Table 2.2 of AFOSH Standard 48-19, *Hazardous Noise Program*. The large increase in noise might also be partially related to a body baffle effect, which occurs when a microphone is held too close to a body.

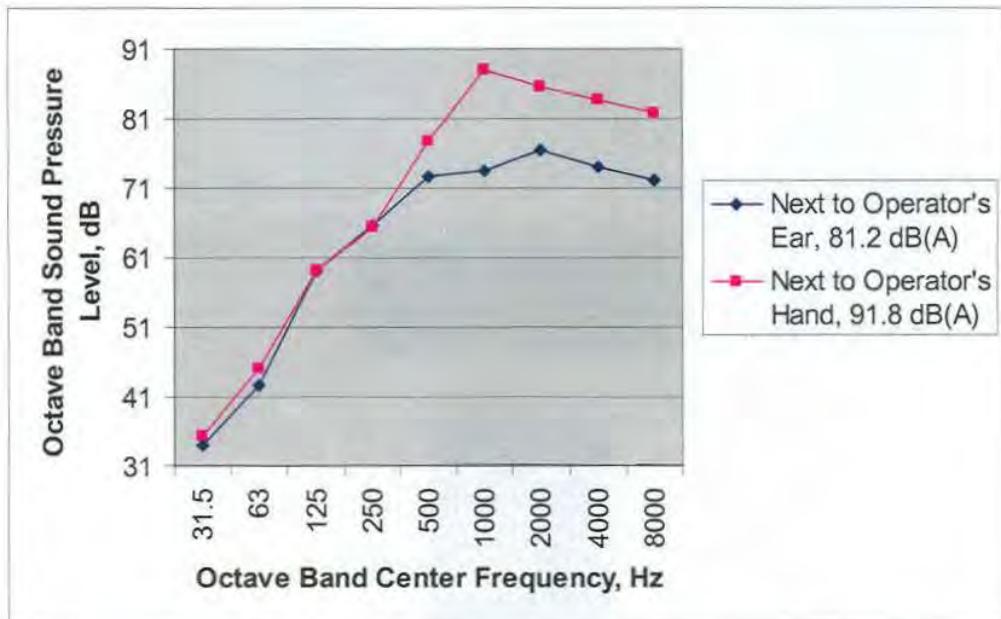


Figure 12. Comparison of the Octave Band Spectrum of the Cleanlaser near the ear and the hand.

c. *Laser Radiation:*

(1) Paragraph 9.1 of ANSI Standard Z136.1 states that measurements are necessary only if any of the following criteria are true: (1) the laser has not been classified by the manufacturer, (2) alterations to the system may have changed its classification, or (3) when the borders of the nominal hazard zone (NHZ) cannot be determined from the analysis of the beam parameters. In this case, none of mentioned criteria were true. To measure the reflected laser light, the ideal detector would have a 7 mm acceptance aperture (to simulate a fully dilated pupil). Making a maximum permissible exposure (MPE) measurement over a larger aperture than 7 mm can introduce errors because any small, intense parts of a radiation pattern are averaged over a larger area. Since this pyranometer has an aperture greater than 7 mm and the response time was too slow, the results were not compared directly with the laser protection standards. AFOSH Standard 48-139, *Laser Radiation Protection Program*, states that it has adopted the current laser protection standards contained in the most recent version of ANSI Publication Z136.1 and the American Conference of Governmental Industrial Hygienists (ACGIH).

(2) The ACGIH threshold limit value (TLV) for the near infrared (IR-A) region protects against thermal injury to the cornea and lens (cataracts) by limiting exposure to 10 mW/cm^2 for durations of 1000 seconds or more. For shorter durations the TLV is time dependent (e.g., 1070 mW/cm^2 for a two second exposure at a wavelength of 1064 nm). The ACGIH TLV is not directly applicable in this case since the laser is not emitting broadband radiation.

(3) In the near infrared region, normal aversion responses to skin-heating usually minimize the potential for skin damage. Nevertheless, gloves and long sleeves shirts should be

worn during operation of the laser. All personnel in the room wore laser eye protection with an optical density of at least seven. Although the LHAZ calculation determined the ocular NOHD was 30.9 cm, we do not believe this is an accurate estimate. The modeling parameters LHAZ uses do not fit the Cleanlaser well. Some of the data describing the Cleanlaser needed to be estimated/converted into more standard laser parameters accepted by LHAZ. Although we tried to error on the conservative side, the actual ocular NOHD is unknown. A System Safety Engineering Analysis (SSEA) was published by HQ AFMC/SES on 24 Jun 04 and that reports a 17 m NOHD for this system. With regard to engineering controls, the laser contained interlocks to shut off the laser if the door to the room was opened. Whether this feature will be incorporated in the field is unclear; however, this control is most likely impractical for use in typical corrosion control facilities and flightlines.

d. *Ventilation:*

(1) The absence of any detectable metal exposures during our sampling indicated that ventilation system was very effective for this type of de-painting task. In typical de-painting operations, workers are not always able to de-paint surfaces that are well below their breathing zone, though. No debris or dust was noticed around the de-painted surface, but the adequacy of this ventilation system should be challenged further during operational use, especially when workers are required to de-paint areas above and closer to their breathing zone.

(2) As expected, the capture velocity of the ventilation system slowly decreased as the HEPA collection bag filled. The Fumex F-2 system uses an indicator light to tell users that the HEPA bag needs to be replaced. Based on these sampling results, it appears the indicator light activates before the capture velocity decreases below an effective level. Our air sampling results also indicated that HEPA bag change out was an insignificant exposure for workers.

6. CONCLUSIONS

a. In the laboratory setting, there were no significant exposures to metals, NO, NO₂, CO, CO₂, HCN, or formaldehyde.

b. We did not find any differences in worker exposure related to the substrate (aluminum vs. composite).

c. When workers are able to de-paint at arms-length away from the surface, at the ear exposures are not at hazardous levels. However, if workers in an operational setting are required to be closer to the surface, they might be exposed to hazardous noise.

d. Laser hazards in this facility were well controlled. Since the laboratory was small and had a door equipped with interlocks, it was fairly simple to ensure workers were protected from direct laser exposures. A laser warning light is also visible outside the laboratory doors when the laser is in use. Having systems like these that protect unaware workers might be difficult to incorporate into traditional de-painting facilities/flightlines.

e. We were unable to find any significant indirect laser exposures; however, the lab's required laser eye protection (minimum OD of 7) is sufficient to protect workers from both indirect and direct exposures.

f. Direct laser hazard exposure is the most serious health concern for this system. Appropriate engineering controls, administrative controls, and personal protective equipment should always be used around this system.

g. The ventilation system used with this laser is appropriate. The system seemed to allow adequate operation time before filter change out was required and automatically notifies operator when filter change out is needed.

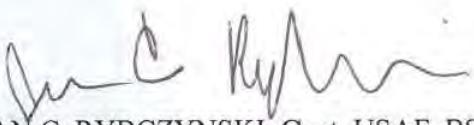
7. RECOMMENDATIONS

a. **Operational exposure assessment are still needed for this system.** As noted throughout this evaluation, the highly controlled laboratory setting does not adequately represent operational exposures. Although sampling for HCN, NO, NO₂, and formaldehyde seems unnecessary in the field, it is recommended that metal sampling and CO monitoring remain part of the field assessments. AFIOH can assist with the operational assessments; continue to work through HQ AFMC/SGPB to obtain our assistance.

b. Although we did not identify any significant airborne exposures, there was a noticeable odor around the process, possibly ozone. The source of this odor should be identified and evaluated as appropriate.

c. The most significant health hazard associated with this system is the possibility of direct laser radiation exposure. We recommend contacting AFRL/HEDO and working with them to obtain a measured NOHD. Controlling this hazard as much as possible with engineering controls for field use is highly recommended. If the NOHD is over a few feet, a system that automatically turns the laser off if a surface isn't within a few inches of the laser head could be added.

8. We appreciate the cooperation of AFRL/MLSC and Anteon personnel during this survey. If you have any questions concerning this report, please contact me at DSN 240-8441 or via email, ian.rybczynski@brooks.af.mil.



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Senior Industrial Hygiene Consultant

Attachments:

1. Pictures of the Laser Stripping
2. Clean CL 120 Q Parameters

Pictures of the Laser Stripping



Atch 1